REPORT DOCUMENTATION PAGE

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
30-03-2016	Final	01 Dec 2009 - 31 Dec 2015

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Origins of the Kuroshio and Mindanao Currents	
	5b. GRANT NUMBER
	N00014-10-1-0268
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
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	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Woods Hole Oceanographic Institution 266 Woods Hole Rd Woods Hole, MA 02543	FINAL

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Office of Naval Research 875 Randolph St Arlington, VA 22203	
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The objectives of this program were quantifying flows and water properties, improving understanding of the dynamics of a bifurcation region, and establishing predictability of the three major currents in the region. The observational approach will have two major thrusts: (1) quantifying the fluxes of mass, heat, and salt in the North Equatorial Current, the Kuroshio Current, and Mindanao Current, and (2) establishing Lagrangian patterns of flow.

15. SUBJECT TERMS

North Equatorial Current, Kuroshio Current, Mindanao Current

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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Unlimited, Unclassified	Unlimited, Unclassified	Unlimited, Unclassified	Unlimited, Unclassified	3	19b. TELEPHONE NUMBER (Include area code) 508-289-3520

Origins of the Kuroshio and Mindanao Currents

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LONG-TERM GOALS

The long-term goal of this work is to understand the ocean's circulation in the bifurcation region of the Kuroshio and Mindanao Currents. The westward flowing North Equatorial Current runs into the Philippine coast and bifurcates into the northward Kuroshio and the southward Mindanao Current. The partitioning of the flow into the Kuroshio and Mindanao Currents is an important observable. Quantifying these flows and understanding bifurcation dynamics are essential to improving predictions of regional circulation, and to characterizing property transports that ultimately affect Pacific climate.

OBJECTIVES

The objective of the OKMC program was to make observations of circulation in the area of the western Pacific Ocean where the North Equatorial Current runs into the western boundary near the Philippine Archipelago and bifurcates into the northward-flowing Kuroshio Current and the southward-flowing Mindanao Current. The observations made during OKMC include glider transects, surface drifters and profiling floats. It is anticipated that the mapped circulation will be used elucidate the ocean dynamics in the bifurcation region, and will help us understand what sets the partioning of the current transports between the Kuroshio and Mindanao Currents. It also provides improved estimates of the transport of the Mindanao Current, which has been poorly observed historically.

APPROACH

Our approach is to produce objective maps of the circulation utilizing the observations made by the surface drifters and profiling floats and combine them with the sea surface height (observed by satellite altimeters and referenced to the newest generation of geoids), and historical surface drifters and Argo float profiles and trajectories.

WORK COMPLETED

The objective mapping procedures have been tested and validated for the time-mean circulation. The mapping technique is different than traditional objective mapping techniques in that we impose physical constraints on the mapped circulation such as no flow through land in order to make it more consistent with the known physics. Over the course of the project, we have rederived the the

parameterization for removing the wind-driven Ekman component of the surface drifter velocities. We also have incorporated the beta-plane geostrophic balance at the Equator into our mapping technique.

RESULTS

Altimeter derived circulation is noisy, and unphysical near the coast. But estimates of the large-scale circulation from velocity (drifter) data alone are too weak due to noise in drifter data and the objective mapping technique. This can be overcome if we include both data types, sea surface height and surface drifter velocities to make a combined estimate. Additionally, the unrealistic flow through topography implied by the sea surface height can be overcome with a dynamic constraint that specifies no flow through topography. An objectively mapped surface circulation in the bifurcation region is shown in Figure 1.

We must also contend with the fact that the observations are not all simultaneous in time and space, and therefore need to be adjusted to the same time period. This can be accomplished by calculating the seasonal cycle and secular trend from the observations. For example, in Figure 2, we show the amplitudes of these terms. It is noteworthy that this region has the highest rate of sea level change anywhere in the world.

IMPACT FOR SCIENCE

It is anticipated that the mapped circulation will be used elucidate the ocean dynamics in the bifurcation region, and will help us understand what sets the partioning of the current transports between the Kuroshio and Mindanao Currents. It will also provide improved estimates of the transport of the Mindanao Current which has been poorly observed historically.

RELATED PROJECTS

Similar maps of the sea surface height and velocity field are being developed for the global ocean for the Argo program (http://www.argo.net) and the Ocean Surface Topography Science team (https://sealevel.jpl.nasa.gov/science/ostscienceteam).
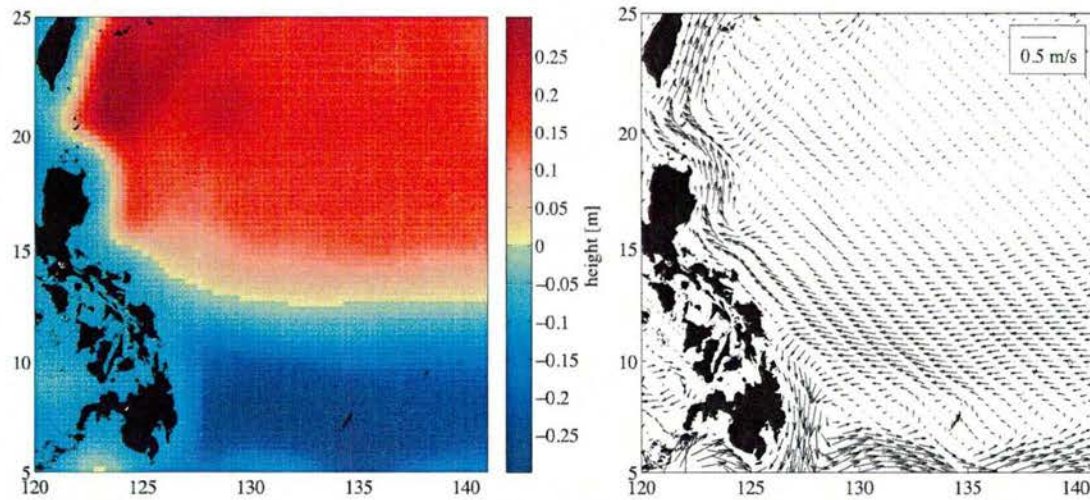
FIGURES/PICTURES

Figure 1: Objectively mapped time-averaged sea surface hieght (right) and surface geostrophic current (left). The mapped fields are estimated by objectively mapping the sea surface height, surface drifters (corrected for Ekman velocities) and the constraint of no flow through topography.
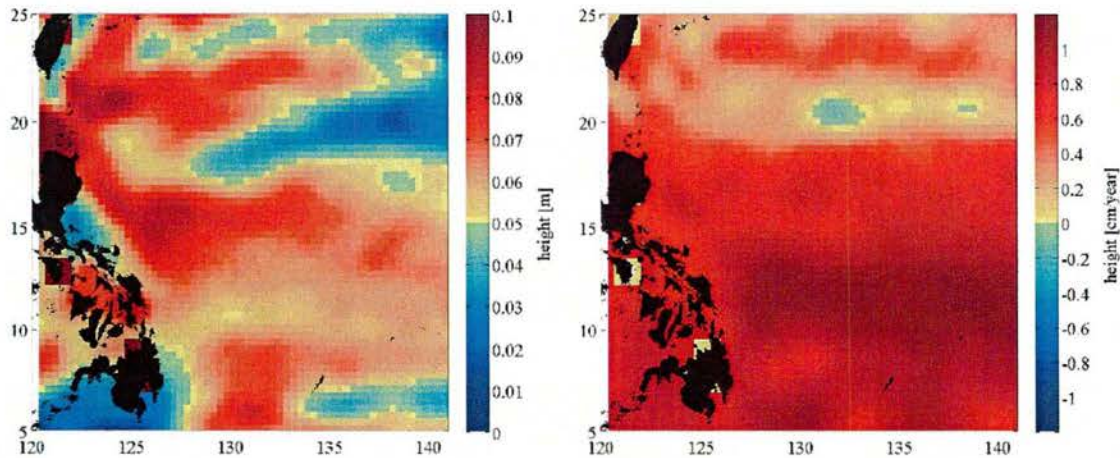

Figure 2: Annual amplitude of the annual cycle (right) and secular trend (left) in sea surface height. Note this region has the largest secular trend of increasing sea surface in the world.

PUBLICATIONS

Lien, R.-C., B. Ma, C. Lee, T. B. Sanford, V. Mensah, L. R. Centurioni, B. D. Cornuelle, G. Gopalakrishnan, J. L. McClean, A. L. Gordon, M.-H. Chang, S. R. Jayne, Y.-J. Yang, 2016: The Kuroshio and Luzon Undercurrent east of Luzon Island. Oceanography, 28, 54–63.

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